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# CONSTANT VELOCITY SLIP JOINT

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| Documents Considered in Evaluating the Patentability: | DE 31 02 871 C2<br>DE-AS 12 84 180<br>DE 36 28 371 A1 |

[Abstract]

A constant velocity slip joint with an inner and an outer joint member, with balls that are guided in grooves with, respectively, axially parallel center lines in the inner and outer joint members, and that serve for transmitting torques, and with balls that are guided in grooves with mutually intersecting center lines and that control a cage on the bisector plane, in which, respectively, balls for transmitting torques and balls for control lie diametrically opposite one another pair-by-pair in perpendicular planes through the joint axis when the joint is not bent.

The invention pertains to a constant velocity slip joint with an inner and an outer joint member, with balls that are guided in grooves with, respectively, axially parallel center lines in the inner and the outer joint members, and that serve for transmitting torques, and with balls that are guided in grooves with mutually intersecting center lines and that serve for controlling a cage on the bisector plane, in which all balls are held such that their centers lie in one plane.

A joint of this type is known from DE-AS 12 84 180. In this case, three torque-transmitting balls are distributed over the circumference and guided in straight grooves while three balls for controlling the cage are guided in intersecting grooves, wherein the latter lie parallel to one another in each of the joint members in a developed view. It is mentioned in the aforementioned publication that the balls guided in the intersecting grooves in the inner and the outer joint members exert an axial thrust relative to one another upon the joint members when the joint is subjected to a torque, i.e., the joint is elongated or shortened depending on the rotating direction. This statement is incorrect, and it can be demonstrated that the relevant characteristics disclosed in this application are misleading. Consequently, this publication describes a joint that, although functional, cannot ensure the attributed effects.

A joint of the aforementioned type is also referred to as an XL joint because the mutually assigned inclined grooves in the outer and the inner joint members respectively form an X in a superimposed developed view and the joint is longitudinally displaceable. Actually, such a joint essentially has two characteristic features. First, it is characterized by a superior axial moveability that requires a low expenditure of force. Second, the axial friction components acting upon the balls when the joint is bent are not balanced, but rather oscillate with respect to their cumulative value such that the joint stimulates axial vibrations when it is bent.

A similar constant velocity joint is disclosed in DE-PS 31 02 871. This joint also contains balls that are guided in straight grooves and balls that are held in intersecting grooves in the inner and the outer joint members. The grooves that are inclined relative to the longitudinal axis and that are provided in the inner and the outer joint members, respectively, are alternately inclined in opposite directions relative to the longitudinal axis. A joint of this type is referred to as a VL joint because the inclined grooves in each individual joint member respectively form a V in a developed view and the joint is longitudinally displaceable. A joint of this type is characterized by internally balanced axial forces when the joint is bent. This is achieved due to the frictional forces acting upon the individual balls. Consequently, such a joint has favorable properties with respect to the stimulation of axial vibrations. On the other hand, the forces required for realizing an axial displacement are comparatively high, such that external stimulation of axial vibrations introduced into the joint cannot be absorbed by easy moveability. To the contrary, a large portion of these external stimulations is transmitted into the drive train.

The present invention is based on the objective of developing a constant velocity slip joint with high torque capacity that combines the advantageous properties of a superior axial moveability and an adequate balancing of the axial forces exerted upon the balls when the joint is bent. Such a constant velocity slip joint has superior properties with respect to the absorption of vibrations and cannot stimulate vibrations when the joint is bent under torque.

This objective is attained by realizing a joint of the initially described type in such a way that balls for the transmission of torque on the one hand, and balls for the cage control on the other hand respectively lie diametrically opposite one another, pair-by-pair in perpendicular planes through the joint axis when the joint is not bent. This means that an XL joint with the advantageous property of low axial displacement forces is additionally developed in such a way that the cumulative frictional forces acting upon the individual balls that could stimulate axial vibrations are largely balanced, namely even when the joint is bent. The objective attained with the invention has not been addressed thus far in joints of the initially described type, because only the static axial displacement forces of constant velocity slip joints were considered important until now, while the problem of vibratory stimulations by the joint was investigated only with respect to the uniformity of the torque transmission.

According to a first preferred embodiment, the grooves for the balls for the cage control are arranged parallel to one another in each joint member in a developed view. This means that an XL joint is realized, wherein this joint is characterized, in contrast to known joints of this type, by a biaxial symmetry. Favorable conditions with respect to the manufacturing technology are achieved due to the parallelism of the inclined ball grooves in each of the joint members. Although the free axial forces during the bending, for example, of a joint with four torque-transmitting balls and four controlling balls, are not equal to zero, they oscillate with only a low amplitude.

According to a second advantageous embodiment, the grooves for the balls for the cage control provided in each joint member are arranged in two groups that respectively comprise one-half of a joint member, wherein the grooves lie parallel to one another within the respective groups in a developed view, and wherein the grooves of the groups are angled oppositely in the longitudinal direction. Although this joint should be referred to as an XL joint, it also has certain properties of a VL joint. An advantageous ease of movement in the axial direction is also achieved in this case, wherein the sum of the axial forces acting upon the individual balls is completely balanced, i.e., becomes zero, when bending a joint with four control balls and four torque-transmitting balls.

With respect to the size of joints used in the drive trains of motor vehicles, i.e., for longitudinal and lateral shafts, the joint according to the invention is preferably provided with four balls for torque transmission and four balls for cage control.

The figures show preferred embodiments of the invention, as well as diagrams for comparing measurement values of the joint according to the invention with those of a joint according to the prior art.

Figure 1 shows a partial longitudinal section through a joint according to the invention;

Figure 2 shows a cross section through a first variation of the joint according to the invention;

Figure 3 shows a developed view of the grooves of a joint according to Figure 2;

Figure 4 shows a cross section through a second variation of the joint according to the invention;

Figure 5 shows a developed view of the grooves of the joint according to Figure 4;

Figure 6 shows a diagram, in which the displacement forces for conventional VL and XL joints are plotted as a function of the torque;

Figure 7 shows a diagram of the joint forces of a conventional VL joint;

Figure 8 shows a diagram of the joint forces of a conventional XL 3 + 3 joint;

Figure 9 shows a diagram of the joint forces of an XL 4 + 4 joint according to the invention illustrated in Figure 2, and

Figure 10 shows a diagram of the joint forces of the XL 4 + 2 x 2 joint according to the invention illustrated in Figure 4.

Figure 1 shows a constant velocity slip joint that consists of an outer joint member 1, an inner joint member 2, torque-transmitting balls 3 and a cage 4 for holding these balls.

According to this figure, the grooves 5 in the outer joint member and the grooves 6 in the inner joint member have axially parallel center lines, i.e., these grooves have a constant depth. The grooves 5 and 6 in the plane of section do not fulfill a control function for the balls 3, i.e., they serve for the transmission of torque only. The figure also shows a cardan shaft 7 that is connected to the inner joint member 2 and secured by means of a ring 8, as well as a sheet metal cap 9 that is connected to the outer joint member 1 and serves as an axial stop for the balls 3. A bellows 10 is simultaneously fixed on this sheet metal cap.

Figure 2 shows the joint according to Figure 1 with the outer joint member 1, the inner joint member 2 and the torque-transmitting balls 3.

In addition to the torque-transmitting balls 3, an identical quantity of controlling balls 11 is provided and held in outer grooves 12 and inner grooves 13 of the respective joint members. These grooves have a constant depth, but are inclined in opposite directions in the respective joint members. The grooves for all controlling balls 11, i.e., the grooves 13 in the outer joint member and the grooves 14 in the inner joint member, are oriented in the same direction in each joint member 1, 2. The figure indicates that the balls are arranged in a centrally symmetrical fashion such that two controlling balls respectively lie diametrically opposite one another when

the joint is not bent and the same number of torque-transmitting balls lies between the controlling balls--as illustrated in the preferred embodiment. The cage is not shown in the figure in order to provide a better overview.

Figure 3 shows a complete developed view of the grooves of the outer joint member that contains four torque-transmitting balls and four controlling balls. The axial parallelism of the grooves 5 for the torque-transmitting balls and the parallelism of the grooves 13 for controlling the balls are clearly illustrated in this figure. The angle of inclination of the inclined grooves lies above the self-locking value, namely at 16° in the embodiment shown.

Figure 4 also shows the outer joint member 1, the inner joint member 2 as well as torque-transmitting balls 3 that lie opposite one another pair-by-pair, respectively. These balls are accommodated in grooves 5 in the outer joint member and grooves 6 in the inner joint member. This figure also shows control balls, pairs of which are respectively oriented in the same direction. These control balls are guided in intersecting grooves 13, 15 in the outer joint member and grooves 14, 16 in the inner joint member. The grooves are realized symmetrically relative to a plane that perpendicularly extends through the axis in the figure. However, the grooves in each of the thusly defined joint halves of the two joint members lie parallel to one another in a developed view. The cage is not shown in this figure in order to provide a better overview.

Figure 5 shows a complete developed view of the grooves of an outer joint member that contains four torque-transmitting and four controlling balls. This figure clearly shows the axial parallelism of the grooves 5 for the torque-transmitting balls and the parallelism of the grooves 13 and 15 for controlling the balls in the two symmetrical groups. The angle of inclination of the inclined grooves lies above the self-locking value, namely at 16° in the embodiment shown.

Figure 6 shows the axial displacement forces for two different joint variations that are plotted as a function of the torque, wherein these values respectively apply to a straight joint (0°) and a bent joint (5°). This figure clearly shows the superiority of XL joints, i.e., joints in which the grooves for controlling the balls lie parallel to one another in both the joint members, in comparison with VL joints, in which inclined grooves with different orientations are provided in each of the joint members.

Figure 7 shows the ball-specific axial forces for a conventional VL joint with six balls, namely for a bending angle of 10° (top) and the free axial force (bottom). This figure indicates that this type of joint is particularly advantageous with respect to the free axial forces; however, one needs to accept the unfavorable displacement forces described with reference to Figure 6 in this case.

Figure 8 shows the ball-specific axial forces (top) and the free axial forces (bottom) for a conventional XL joint with six balls, namely for a bending angle of 10°, wherein the axial forces

are plotted as a function of the angle of rotation. According to this figure, free axial forces that oscillate with a significant amplitude are generated in a joint of this type.

Figure 9 shows the ball-specific axial force (top) and the free axial force (bottom) for an XL joint according to the invention with four torque-transmitting grooves and four controlling grooves according to Claims 1 and 2. With respect to absolute values other than zero, the free axial force is nearly constant, i.e., only slight vibratory stimulations occur. The low displacement forces of this joint variation in accordance with Figure 6 elucidate the altogether advantageous function of this joint.

Figure 10 shows the ball-specific axial force and the free axial force for an XL joint according to the invention with four torque-transmitting balls and four controlling balls according to Claims 1 and 3. This figure shows that the resulting axial force becomes zero so that this joint variation is not subject to any vibratory stimulations.

<u>Claims</u>

1. A constant velocity slip joint with an inner and an outer joint member, with balls that are guided in grooves with, respectively, axially parallel center lines in the inner and the outer joint members, and that serve for transmitting torques, and with balls that are guided in grooves with mutually intersecting center lines and that serve for controlling a cage on the bisector plane, in which all balls are held such that their centers lie in one plane, characterized by the fact that the balls (3) for transmitting torques and the balls (11) for controlling the cage, respectively, lie diametrically opposite one another pair-by-pair in perpendicular planes through the joint axis when the joint is not bent.

2. The joint according to Claim 1, characterized by the fact that the grooves (13, 14) for the balls (11) for the cage control lie parallel to one another in each of the joint members (1; 2) in a developed view. (Figure 2)

3. The joint according to Claim 1, characterized by the fact that the grooves (13, 14, 15, 16) for the balls (11) for the cage control are arranged in each of the joint members (1; 2) in two groups that respectively comprise half of a joint member, wherein the grooves for the cage control lie parallel to one another within the respective groups in a developed view, and wherein the groups are oppositely angled in the longitudinal direction. (Figure 4)

4. The joint according to one of Claims 1-3, characterized by the fact that four balls (3) are provided for the transmission of torque and four balls (11) are provided for the cage control.

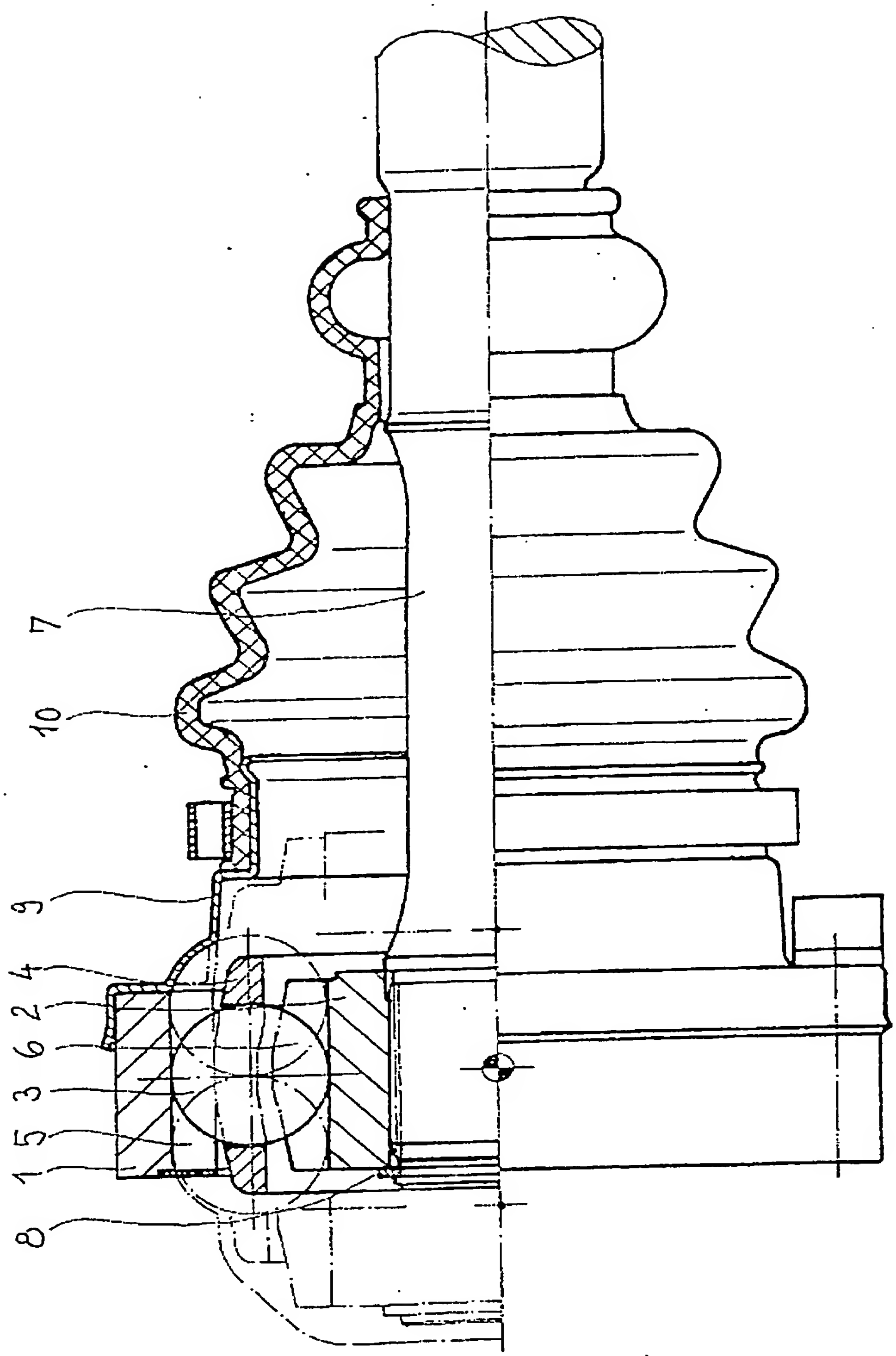



Fig. 1

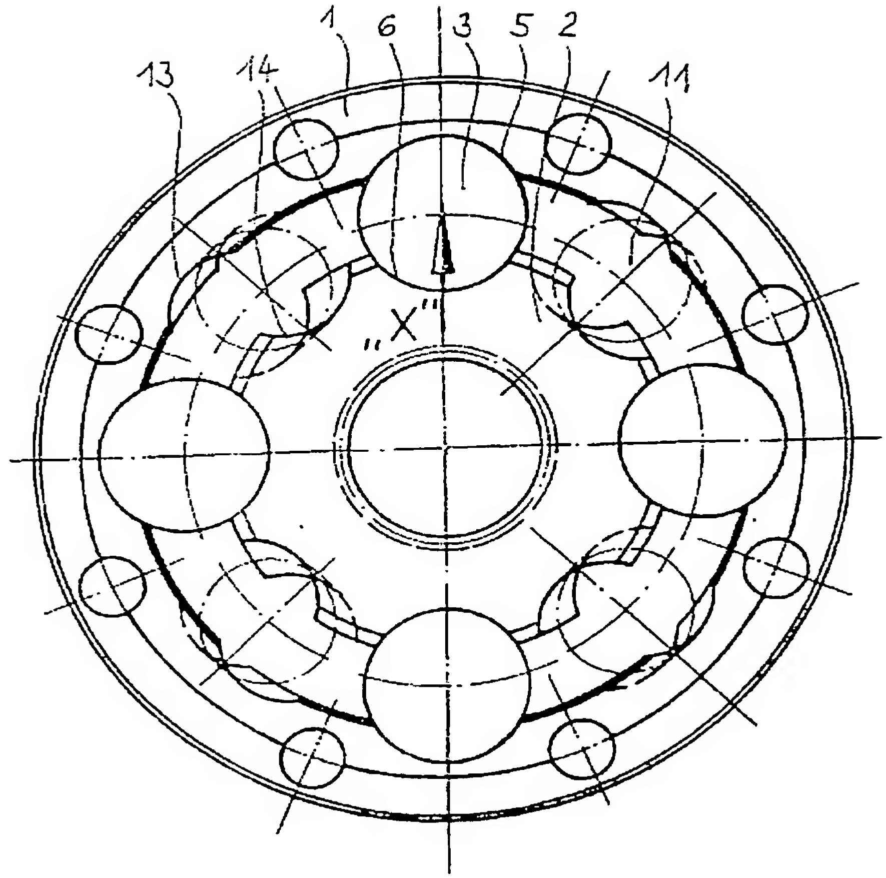



Fig. 2

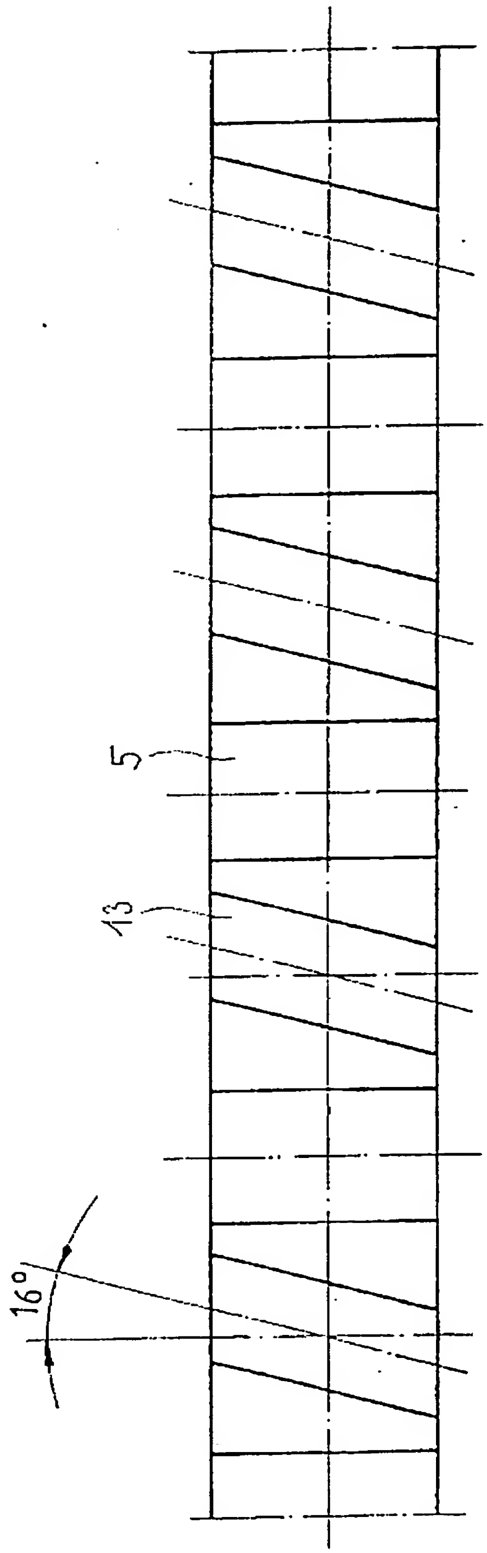



Fig. 3

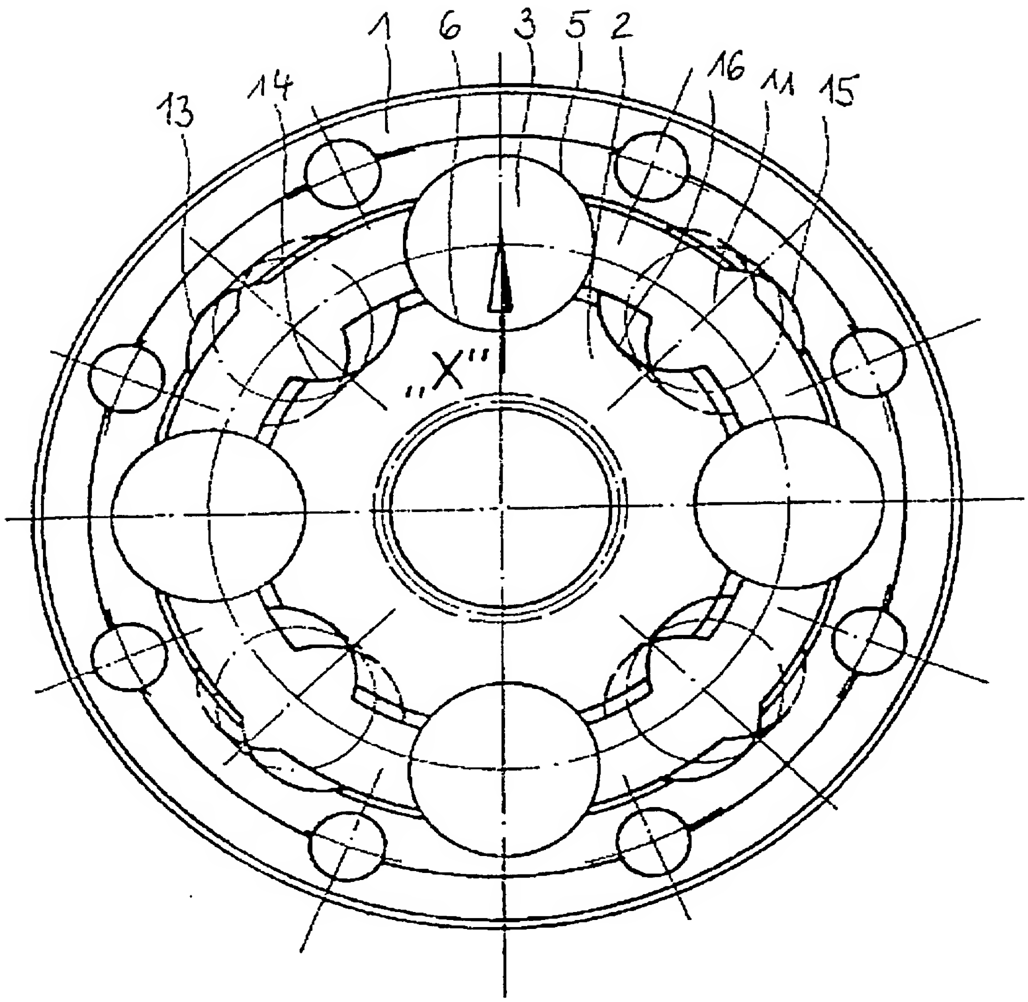



Fig. 4

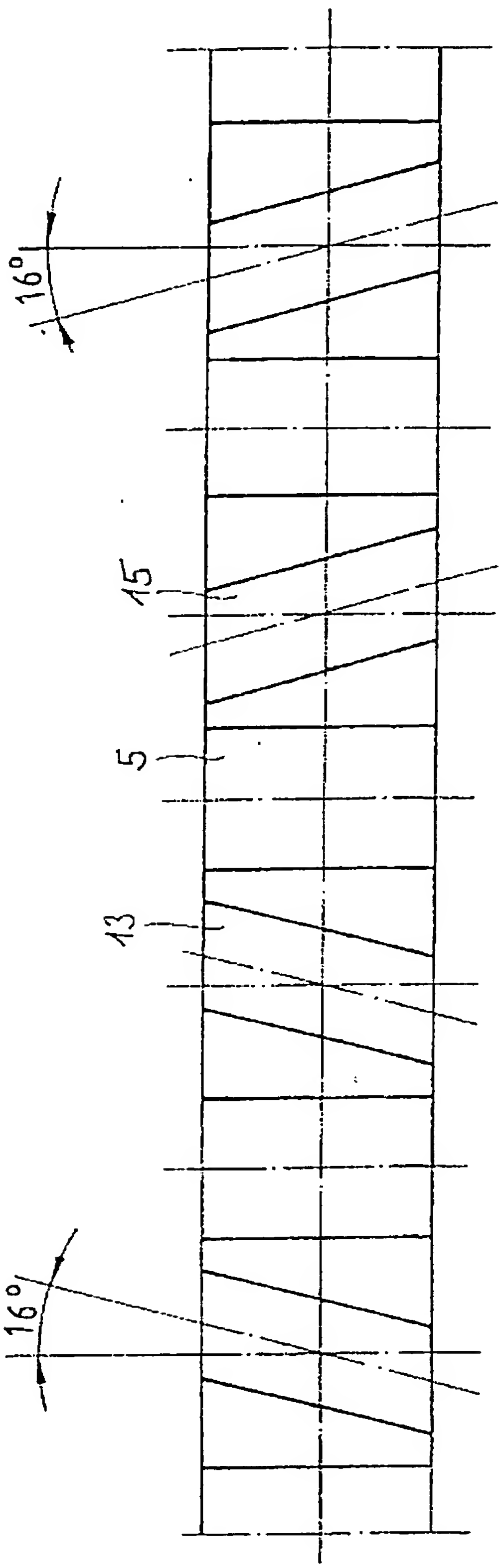



Fig. 5

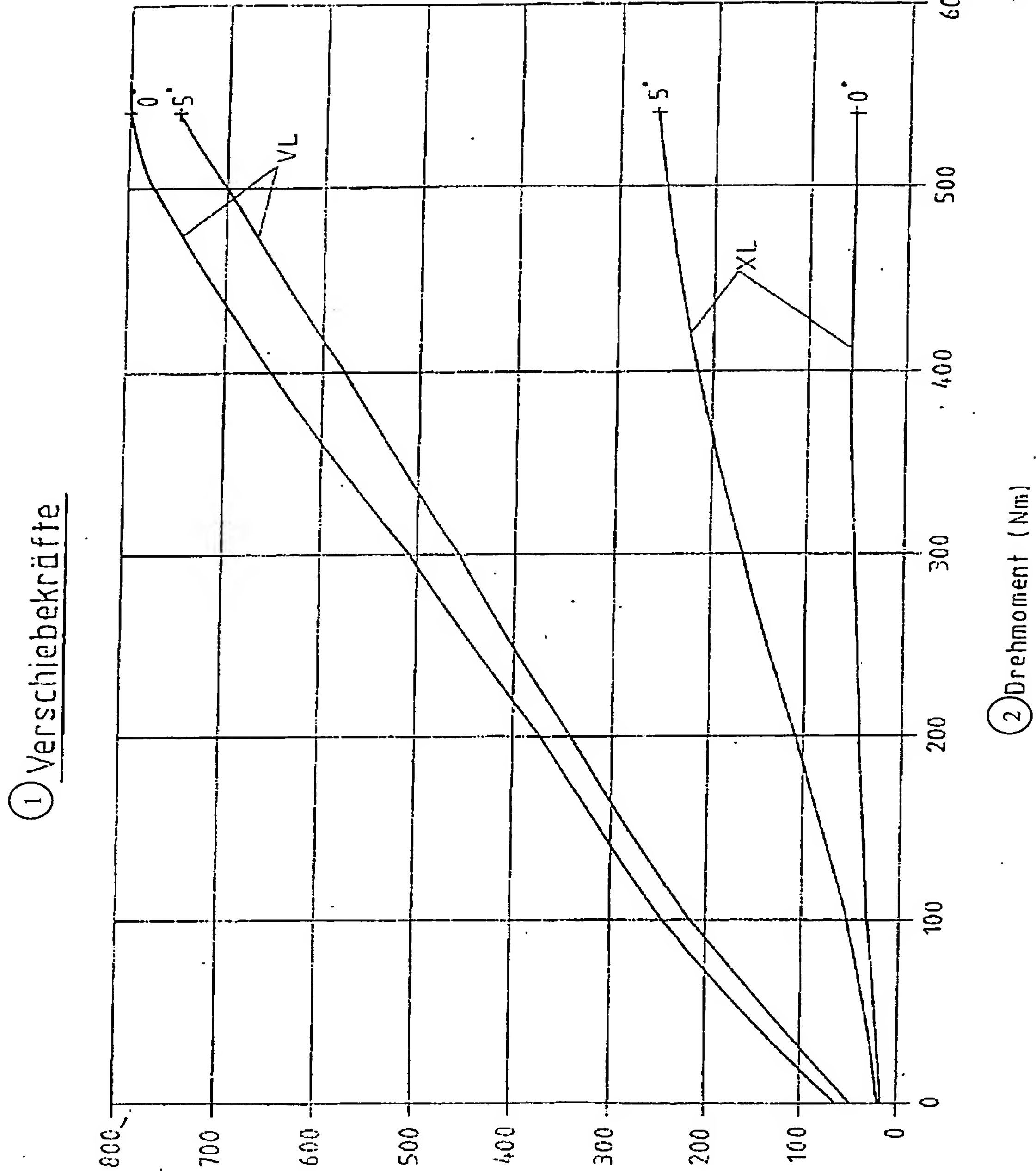



Fig.6

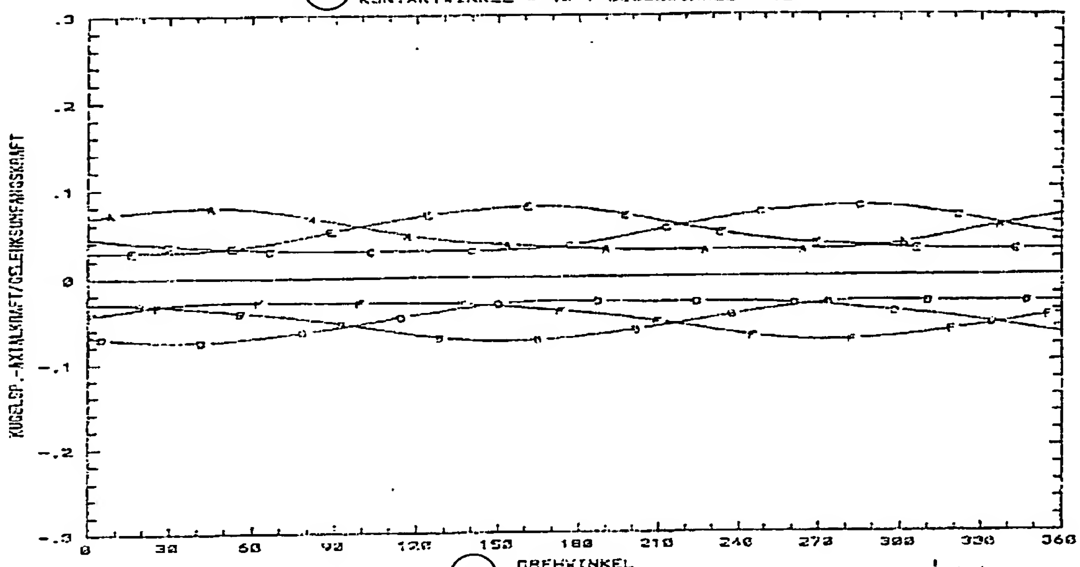
Key: 1 Displacement forces

2 Torque

1 kugelspezifische Axialkraft im VL-Gelenk

2 KONTAKTWINKEL = 40 , BEUGEWINKEL = 10

3

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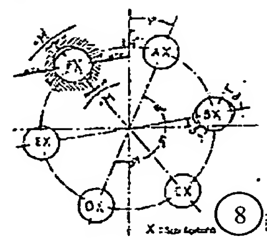
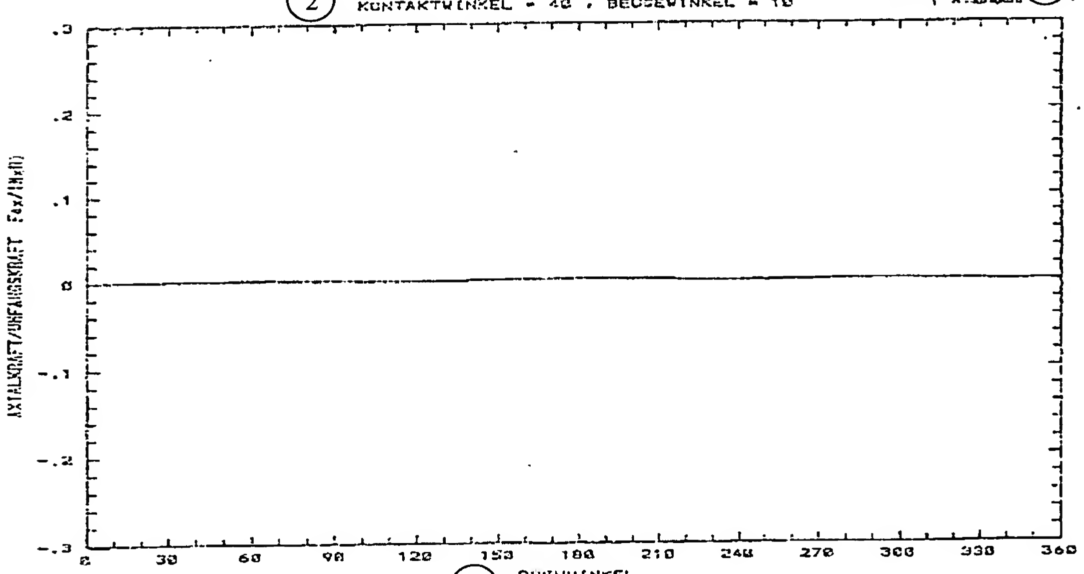



5 freie Axialkraft aus dem VL-Gelenk

8

2 KONTAKTWINKEL = 40 , BEUGEWINKEL = 10

6




4

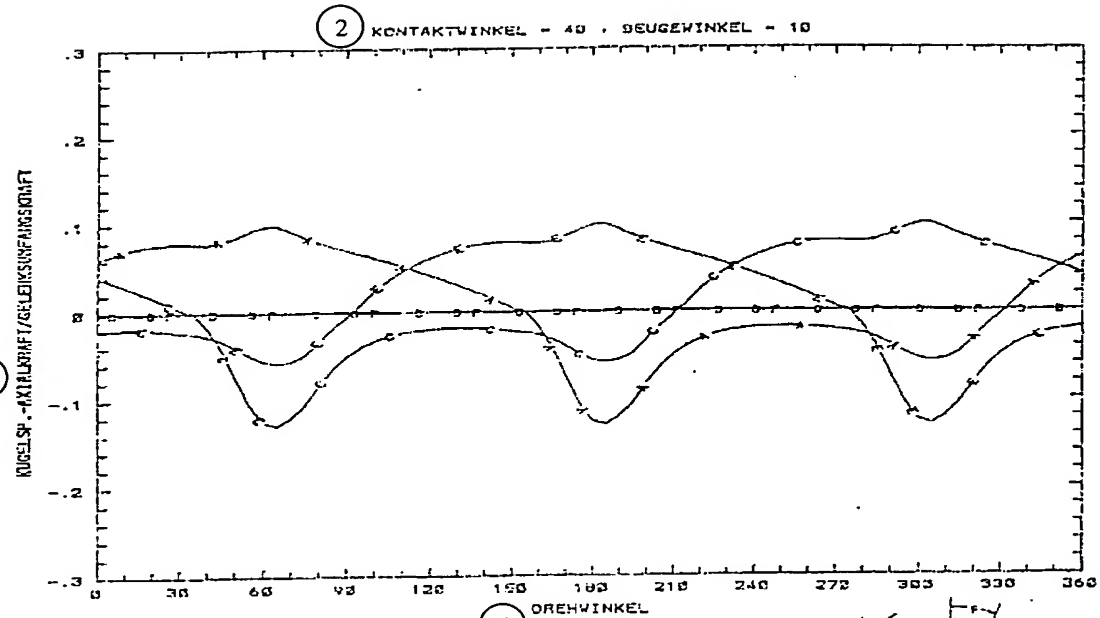
7 Axialkräfte im VL-Gelenk

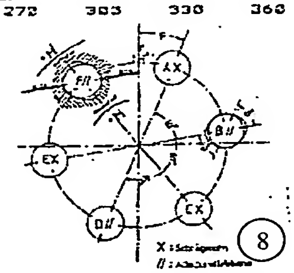
Fig.7

Key:

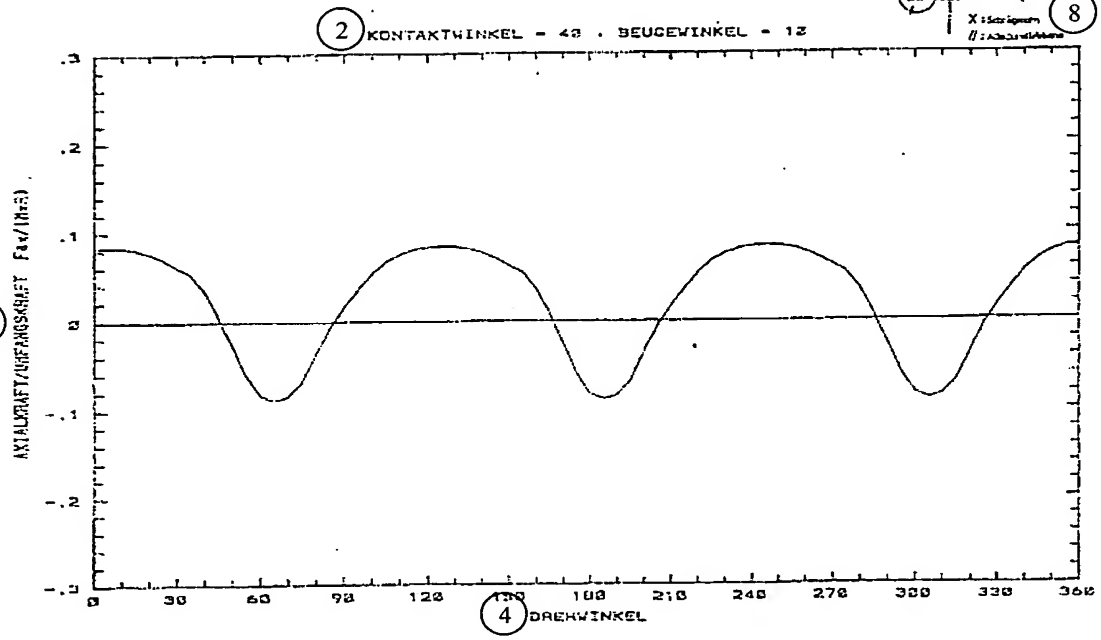
1 Ball-specific axial force in VL joint
2 Contact angle = 40, bending angle = 10
3 Ball-specific axial force/joint radial force
4 Angle of rotation
5 Free axial force from VL joint
6 Axial force/radial force
7 Axial forces in VL joint
8 X: transverse path

1 kugelspezifische Axialkraft im XL 3+3-Gelenk




5 freie Axialkraft aus dem XL3+3-Gelenk




7 Axialkräfte im XL3+3-Gelenk

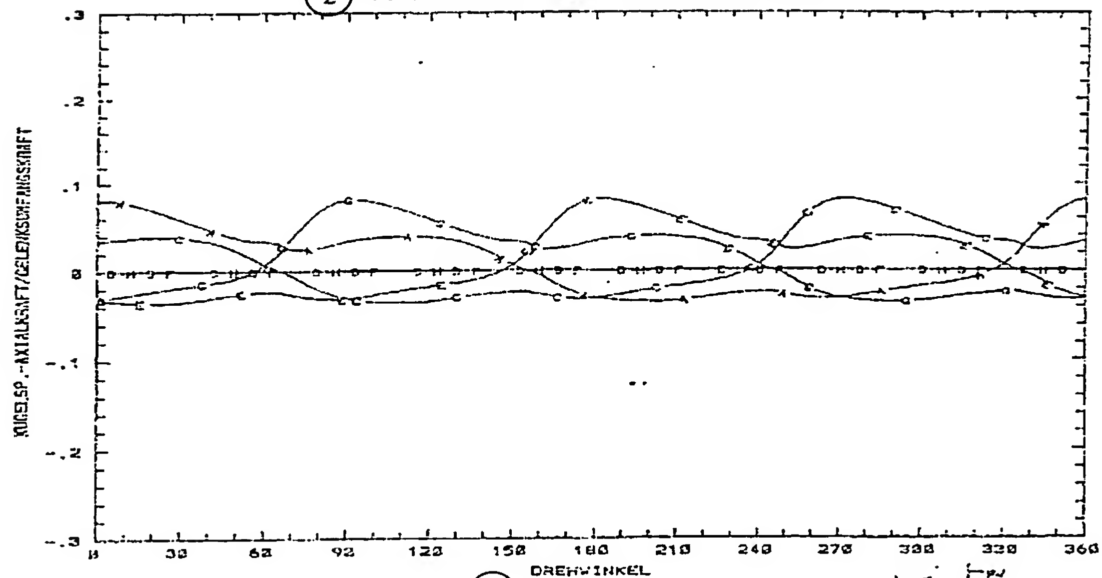
Fig. 8

| | | |
|---|---|---|
| Key: | 1 | Ball-specific axial force in XL 3 + 3 joint |
| | 2 | Contact angle = 40, bending angle = 10 |
| | 3 | Ball-specific axial force/joint radial force |
| | 4 | Angle of rotation |
| | 5 | Free axial force from XL 3 + 3 joint |
| | 6 | Axial force/radial force |
| | 7 | Axial forces in XL 3 + 3 joint |
| | 8 | X: transverse path |

1 kugelspezifische Axialkraft im XL4+4-Gelenk

2 KONTAKTWINKEL = 40 , BEUGEWINKEL = 10

3

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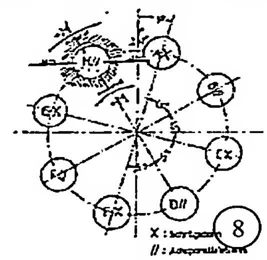
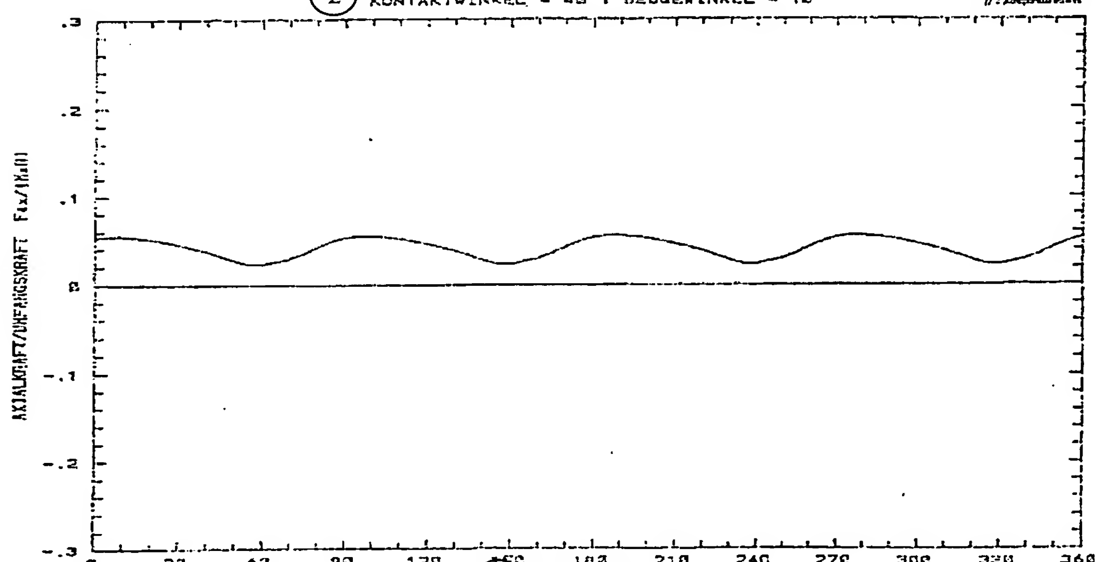


5 freie Axialkraft aus dem XL4+4-Gelenk

8

2 KONTAKTWINKEL = 40 , BEUGEWINKEL = 10

6



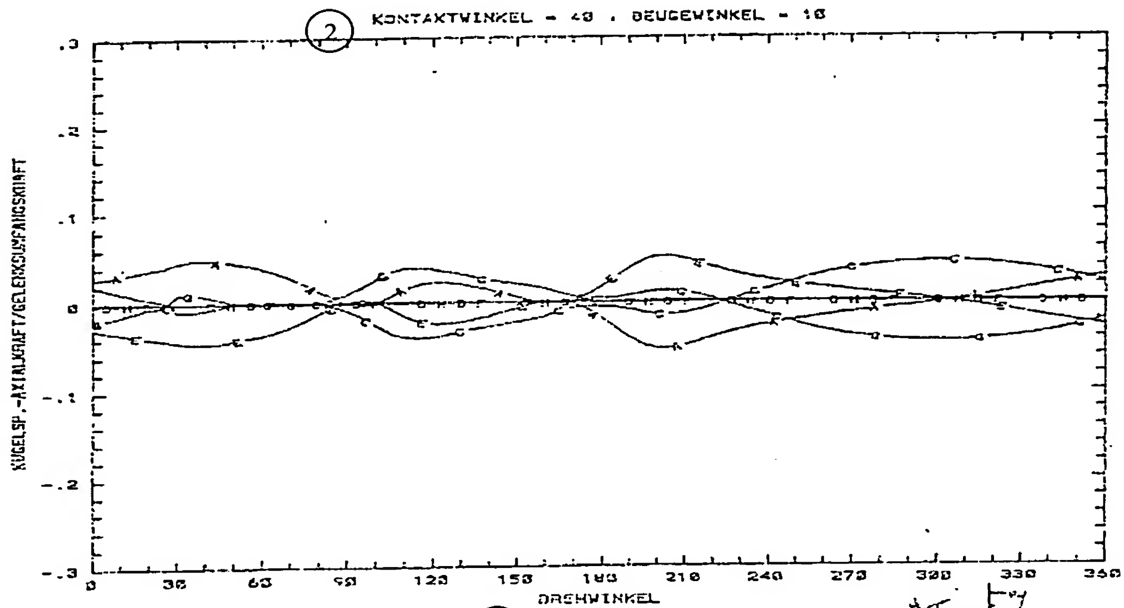

4 DREHWINKEL

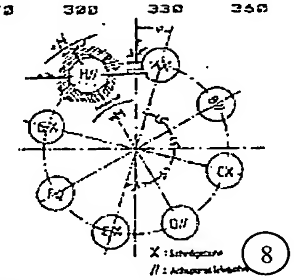
7 Axialkräfte im XL4+4-Gelenk

Fig. 9

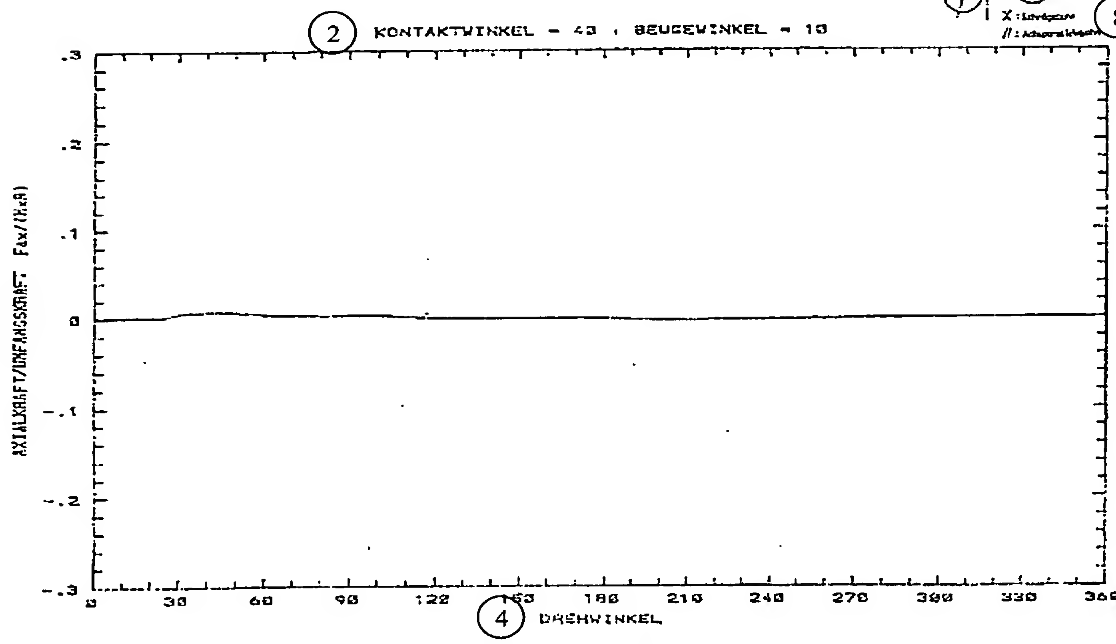
| | | |
|---|---|---|
| Key: | 1 | Ball-specific axial force in XL 4 + 4 joint |
| | 2 | Contact angle = 40, bending angle = 10 |
| | 3 | Ball-specific axial force/joint radial force |
| | 4 | Angle of rotation |
| | 5 | Free axial force from XL 4 + 4 joint |
| | 6 | Axial force/radial force |
| | 7 | Axial forces in XL 4 + 4 joint |
| | 8 | X: transverse path |

1 kugelspezifische Axialkraft im XL4+2x2-Gelenk




5 freie Axialkraft aus dem XL4+2x2-Gelenk




7 Axialkräfte im XL4+2x2-Gelenk

Fig. 10

| | | |
|---|---|---|
| Key: | 1 | Ball-specific axial force in XL $4 + 2 \times 2$ joint |
| | 2 | Contact angle = 40, bending angle = 10 |
| | 3 | Ball-specific axial force/joint radial force |
| | 4 | Angle of rotation |
| | 5 | Free axial force from XL $4 + 2 \times 2$ joint |
| | 6 | Axial force/radial force |
| | 7 | Axial forces in XL $4 + 2 \times 2$ joint |
| | 8 | X: transverse path |